defined in terms of the overall population, but it might actually lower the average productivity per hour of work. Finally, other considerations besides productivity may militate against the use of such measures.

INVESTMENTS IN HUMAN CAPITAL: EDUCATION AND TRAINING

How Important Is Education?

Investments that increase the education, training, health, and mobility of the labor force tend to enhance labor productivity. Education and training make workers more skilled and therefore more productive. In addition, education--particularly basic or general education--helps workers to adjust to new technologies. Expenditures in these areas are a kind of investment because they yield an economic return over a period of time. But it is very difficult to assess the precise contribution of these factors to productivity growth. For example, there is great uncertainty about the effect of added years of schooling on labor productivity, and the time lag between the investment and the effect is relatively long. During the late 1950s and 1960s, there was much research on the role of human capital in economic growth. 6/ This attention may have been a contributing factor in the rapid increases in U.S. investments in education, training, and health. In more recent years, however, some students of the subject have become skeptical as to the degree to which such investments actually increase productivity. 7/ In

---

6/ See, for example, Theodore W. Schultz, "Investment in Human Capital," American Economic Review, vol. 51, no. 1 (March 1961), pp. 1-17; Gary S. Becker, "Underinvestment in College Education?" American Economic Review Papers and Proceedings, vol. 50, no. 2 (May 1960), pp. 346-54; and Edward F. Denison, The Sources of Economic Growth in the United States (Committee for Economic Development, 1962).

7/ Lester C. Thurow and Robert E.B. Lucas, The American Distribution of Income: A Structural Problem, prepared for the U.S. Congress, Joint Economic Committee (1972), Chapters IV and V; Herbert Gintis, "Education, Technology, and the Characteristics of Worker Productivity," American Economic Review Papers and Proceedings (May 1971), pp. 266-79; and Henry M. Levin, "Economic Democracy, Education, and Social Change" (Center for Educational Research, School of Education, Stanford University, June 1979; processed).

the United States in particular, investment in human capital may have reached the point of diminishing returns in some cases.

The schooling of U.S. workers increased substantially during the postwar period (see Table 19). The proportion of the labor force with four or more years of higher education increased from 11.7 percent in 1965 to 17.7 percent in 1978. In addition, the proportion of workers at the bottom of the education scale declined. Many workers, however, still lack basic skills, such as literacy. While every country has its proportion of very unskilled workers, that group in the United States may be relatively larger than in some other industrialized countries, such as Germany, France, and Sweden.

There is disagreement as to the relative importance of education in improving productivity. According to one study, it was one of the most important factors contributing to productivity increases in the postwar period--considerably more important than investments in physical capital. 8/ But most estimates of the impact of education on productivity are based on cross-section studies of the relation between earnings and years of school completed at a point in time. This ignores other factors, such as ability and family background, which tend to be quite highly correlated with the number of years of schooling achieved. 9/

8/ Edward F. Denison, Accounting for Slower Economic Growth (Brookings Institution, 1979), p. 94. Educational upgrading was estimated to have raised productivity growth by an estimated 0.52 percentage point per year from 1948 to 1973, and 0.88 percentage point per year from 1973 to 1976. By comparison, physical capital was estimated to have contributed 0.39 percentage point and 0.27 percentage point, respectively. The Denison study assumes that some 40 percent of the difference in earning associated with schooling is due to other factors. But in actuality their importance could be more or less than 40 percent, and that would affect the conclusion about the contribution of education to productivity growth.

9/ Some analysts believe that employers use education merely as a screening device for hiring and that, after some point, more schooling may even have a counterproductive impact on productivity in some situations. See Ivar Berg, The Great Training Robbery (Beacon Press, 1971).

TABLE 19. SCHOOL YEARS COMPLETED BY THE LABOR FORCE

	Percent Distribution by School Years Completed					Median School Years Completed
		High School		College		
	8 or Less	1-3	4	1-3	4 or More	
1940	49.6	18.4	19.7	6.5	5.7	9.1
1957	31.8	19.8	30.5	8.8	9.2	11.8
1965	22.0	19.4	36.4	10.6	11.7	12.2
1973	12.8	15.9	41.5	15.0	14.7	12.5
1978	9.0	13.9	41.4	17.9	17.7	12.7

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Educational Attainment of Workers--Some Trends from 1973 to 1978, Special Labor Report 225 (1979), Table A.

To the extent that education does have an important bearing on the productivity of workers at one point in time, the question remains how much increases in the schooling of workers over time affect productivity. Unless more and more jobs require increased education, a substantial and growing proportion of young college graduates may have to accept jobs that in the past were filled by workers with less education.

But schooling itself may have less substance than it formerly did. A good many employers seem to think that the quality of education has declined, and some standardized test scores tend to support this view. For example, average scores on the Scholastic Aptitude Test given to students entering college have shown a downward trend since the mid-1960s. Some of the decline can be explained by the fact that an increased proportion of students--and consequently a less select group--are continuing on to college. But even after taking account of the changes in the socioeconomic composition of students, a substantial part of the decline in test

scores remains to be explained. 10/ A particular grade level of schooling today apparently carries a lower educational performance than it did 15 or 20 years ago.

Another argument made against further investment in higher education is that the economic returns from higher education may have declined in recent years--in part because of the very rapid growth in the number of new college graduates. 11/ Evidence on this is mixed. The Current Population Survey suggests that the income of young college graduates declined relative to that of young high school graduates between the late 1960s and the 1970s. But some analysts maintain that the decline was not related to education and that, after allowing for noneducational factors that affect earnings, there has been no decline in the earnings differential enjoyed by college graduates. 12/

But even if the private returns from a college education have not declined, the social returns may have. This is because the private returns depend to a large extent on the differential in earnings associated with college graduation. However, if persons with less education are bumped down the job ladder to accommodate an influx of college graduates, the social returns from higher education may have fallen even if the private returns have not. There has clearly been an increase in the proportion of college graduates working at jobs that in the past did not require a

---

10/ See College Entrance Examination Board, On Further Examination, Report of the Advisory Panel on the Scholastic Aptitude Test Score Decline (1977).

11/ See Richard B. Freeman, "Overinvestment In College Training?" Journal of Human Resources, vol. X, no. 3 (Summer 1975), pp. 287-311. The decline in the proportion of youths enrolled in college after the late 1960s may be an indication that the economic returns from college may have diminished, although the end of the draft may also have been a contributing factor.

12/ See, for example, Russell W. Rumberger, "The Economic Decline of College Graduates: Fact or Fallacy?" and the response by Richard B. Freeman, in Journal of Human Resources, vol. XV, no. 1 (Winter 1980), pp. 99-112 and 124-42.

college education. (In some cases, however, jobs can be upgraded to take advantage of more skilled workers, for example, by adopting more sophisticated technology.)

The current labor market situation for college graduates shows imbalances in particular sectors that make generalization difficult. Overall, there is little indication of underinvestment in higher education. According to one recent study, the number of jobseekers with higher education in the decade ahead is likely to grow considerably more rapidly than the number of jobs that have traditionally been filled by college graduates. 13/ At the same time, there seem to be shortages in some highly skilled occupations such as engineers and certain kinds of scientists.

The labor market for highly skilled workers is flexible, but adjustment takes time. In occupations where there are shortages, as among engineers and certain types of scientists, salaries have been increasing more rapidly than in others. Correspondingly, the number of students majoring in engineering is growing, and persons with some engineering training who were not previously working as engineers are now shifting to engineering jobs. The process of market adjustment to the scarcity of engineers also includes considerable on-the-job training. 14/

Training

In addition to formal education, training and work experience are also important factors that influence labor productivity. But it is very difficult to measure such investments or to isolate their economic returns. Economists distinguish two types of training: "general training" that makes a worker more valuable to businesses in general, and "specific training" that increases the productivity of the worker but only to his employer. In

---

13/ Janet L. Norwood, "The Outlook for College Graduates Through 1990," Occupational Outlook Quarterly, vol. 23, no. 4 (Winter 1979), pp. 2-7.

14/ For a discussion of the labor market for engineers, see Glen G. Cain, Richard B. Freeman, and W. Lee Hansen, Labor Market Analysis of Engineers and Technical Workers (Johns Hopkins University Press, 1973).

general, the employer pays for investments in specific training and the employee pays for general training.

One important factor that influences an employer's decision to invest in training for an employee is the likelihood of a continuous relationship. In turn, this depends on whether the worker seems likely to quit after a short period of time or whether the employer may wish to lay off workers because of a recession.

In addition, training and other forms of worker-upgrading are importantly affected by the amount of slack or tightness in labor markets. 15/ During boom periods, workers and firms invest heavily in training. Conversely, when labor markets are slack as they have been during a substantial part of the period since 1973, the incentives for investing in training are weakened. This may lead to underinvestment in training from a longer-run perspective.

Finally, the way some government income transfer programs are structured may discourage investments in training to the extent that they inadvertently encourage high turnover among employees or encourage layoffs during slack periods.

Policy Options

One may conclude that increased federal spending on higher education does not appear to be a very effective way of increasing productivity. In part, education has probably reached the point of diminishing returns. It is important for productivity that literacy rates be high, but there is no reason to suppose that college-educated workers make better production workers. And, part of federal spending on higher education supports education of a kind that does not contribute to productivity growth.

To some extent, current federal policy may overemphasize higher education compared with investments in training or in secondary education. Thus, the Middle Income Student Assistance

---

15/ See Arthur M. Okun, "Upward Mobility in a High Pressure Economy," Brookings Papers on Economic Activity (1973:1), pp. 207-61.

Act makes all full-time students in postsecondary education eligible for subsidized loans--an expenditure of resources that might, from the standpoint of economic growth, be better employed elsewhere.

Instead of increasing outlays, an alternative strategy would be to reallocate expenditures within the human resources area of the budget, with more devoted to investments in training, improving the quality of secondary education, and selective areas of higher education.

Some policies that might encourage skill development include:

- Increased training--more funding for Title II B and C of the Comprehensive Employment and Training Act (CETA), and for remedial education and training for youths to help them get jobs. H.R. 6711, which passed the House, would have authorized approximately $2 billion for youth employment-education programs; 16/

- Liberalization of the Basic Educational Opportunity Grant (BEOG) program to include students who are enrolled in education or training programs less than half time;

- Measures to encourage investment in training, such as tax credits for firms;

- Modification of government programs to encourage continuous employment with the same firm--for example, by paying unemployment benefits to employees working on a reduced work week.

Changes in CETA. The current emphasis of programs under CETA is on creating jobs for the disadvantaged. Increased emphasis might be placed on training and skill development for the disadvantaged. In addition, eligibility might be broadened to provide retraining for workers being displaced by economic forces such as technological change, import competition, or changes in energy prices.

16/ For a discussion of federal policy in the area of youth employment, see Congressional Budget Office, Youth Employment and Education: Possible Federal Approaches (July 1980).

The use of CETA Title II funds for this purpose might require some modifications in eligibility standards and in the distribution of funding. Title IIC now provides funds to prime sponsors for retraining or upgrading displaced workers, but only a small proportion of Title II training funds can be used for IIC. In addition, the workers who benefit must be unemployed, a requirement that may not conform to the need to retrain workers. Finally, the prime sponsors who currently administer the CETA funds are primarily municipal and state governmental bodies that tend to focus on the disadvantaged rather than on the regular labor force.

Evaluations of the government's training programs suggest that they tend to increase the earnings of those who are trained. 17/ It is not clear, however, whether they increase earnings enough to justify the cost of the programs, based on economic criteria alone.

Liberalization of BEOGs. The BEOG program provides grants to lower-income students to continue their postsecondary education or training, but only to those who are enrolled at least half time. If eligibility were extended to persons enrolled less than half time, it would probably include more students engaged in applied training than it does at present.

Tax Credits for Training. A tax credit to business firms for their training expenses might be a means of encouraging firms to invest more in skill development. Small firms in particular may lack incentive to invest in training because their workers are more likely to leave for better jobs elsewhere. A difficulty with the tax credit approach is that it might raise administrative problems--for example, determining what is a legitimate training expense. 18/

17/ See, for example, Michael E. Borus, "Assessing the Impact of Training Programs," in Eli Ginzberg, ed., Employing the Unemployed (Basic Books, 1980), pp. 25-40; and Mathematica Policy Research, Inc. Evaluation of the Economic Impact of the Job Corps Program, prepared for the U.S. Labor Department (April 1980).

18/ Current law provides an "employment tax credit" to cover some of the cost of hiring certain groups of disadvantaged workers, including low-income youths. See the Revenue Act of 1978.

Changes in Unemployment Insurance. Some government programs inadvertently encourage turnover in the labor market, and thereby discourage training and skill retention. For example, the unemployment insurance system, as it currently operates, encourages firms to lay some workers off completely during cyclical downturns, rather than go on a reduced workweek. This is because in most states unemployment benefits are reduced dollar-for-dollar if the recipient works part time, or may be discontinued entirely if the worker goes on a slightly reduced workweek. California has been experimenting with an unemployment insurance program that in certain cases permits plants to go on a reduced workweek, with workers entitled to prorated unemployment benefits. H.R. 7529 would encourage other states to follow the California model.

HELPING WORKERS ADAPT TO ECONOMIC CHANGE

The process of economic growth and of productivity growth involves major adjustments on the part of workers and businesses to economic change--adjustments that are frequently painful. In the postwar period, economic change has led to the exodus of millions of workers from U.S. agriculture, and of thousands from the New England textile industry. Such structural changes are brought about by the rise of foreign competition, by technological change, and by changes in the demand for goods. Understandably, workers and businesses frequently fear these changes and seek to avoid them or slow them down, or to cushion their impact.

Government policies in this area tend to reflect several competing objectives: those of adapting to economic change, of mitigating hardship, or of attempting to prevent or slow the changes. One way to promote productivity growth would be to strengthen policies and programs that aid in the process of adjustment and to modify existing policies that may be inhibiting long-run adjustments to economic change. This would stimulate productivity in at least two ways: by raising the productivity of displaced workers, and by encouraging workers to accept new technologies without fear of unemployment as a consequence. 19/

19/ Some observers believe that the emphasis on job security in some other industrialized countries, such as Japan, encourages greater willingness on the part of labor to accept technological change than in the United States.

Training Programs. In the field of training, some existing programs might be modified. As noted above, the current focus of CETA programs is on the disadvantaged, but it could be modified to include workers experiencing difficulties in adjusting to technological change. 20/ Currently, Title IIC of the Comprehensive Employment and Training Act (CETA) provides training for workers displaced by technological change, although it constitutes a rather small part of the CETA programs compared with providing work experience and public service employment.

Another program that could be modified to give increased emphasis to retraining is the Trade Adjustment Assistance program. The program provides income assistance and training for workers unemployed because of international competition. As it has functioned, however, not many workers have been retrained so far. 21/

Migration Assistance. Many unemployed workers might be able to find jobs in other parts of the country. Several pilot projects were undertaken during the 1960s to test the feasibility of assisting workers in relocating through placement, training, and relocation grants. But the results were inconclusive, in part because the experience of the migrants could not be followed over a sufficiently long period of time. Most of the migrants experienced increases in earnings--for one thing they had to have a job in the new area before they were assisted in moving--but two months after migration about one-sixth of them had returned to their original communities. What happened in ensuing months is not known. For this kind of investment to "pay," the migrants would have to

---

20/ The rationale for the original Manpower Training and Development Act (MDTA) was to assist workers in adjusting to technical change. During the 1960s, the focus of employment policy changed to the problems of the disadvantaged. In addition, the general prosperity of the 1960s may have obscured longer-run problems of economic adjustment.

21/ For an analysis of this program, see Government Accounting Office, Restricting Trade Act Benefits to Import-Affected Workers Who Cannot Find a Job Can Save Millions (1980).

experience higher earnings than the control group for several years. 22/

Unemployment Insurance. The payment of unemployment insurance benefits over an extended period of time can deter workers from making job adjustments that in the long run would improve productivity. One proposal that has not yet gained favor would seek to minimize this effect by replacing monthly payments with a lump sum grant. If a displaced worker did not find a job after a specified period, reduced monthly payments might then begin. Another approach would be to offer training along with the benefits.

Reducing Barriers to Opportunities. Policies that help to remove barriers to developing and using skills can also help to raise labor productivity. These barriers include:

- o Lack of access to adequate schools;
- o Location in depressed labor markets;
- o Monopoly practices that prevent free entry of labor into occupations and industries; and
- o Discrimination based on race, sex, or age.

WORK EFFORT AND EFFECTIVENESS

Some observers feel that worker attitudes may be a factor in the productivity slowdown. One line of thought is that higher taxes have impaired peoples' interest in working hard or taking on increased responsibility. Another is that people have become less attentive to their jobs--a reflection of changing social attitudes. But there is not much hard evidence to suggest a deterioration of worker effort. For example, the rate of absenteeism for full-time nonfarm workers--admittedly an indirect measure of work effort--was roughly the same in 1978 as in 1973 (see Table 20). Another indicator, the quit rate among workers in manufacturing,

---

22/ Charles K. Fairchild, Worker Relocation: A Review of U.S. Department of Labor Demonstration Projects, Final Report to the Manpower Administration, U.S. Department of Labor (April 1970; Contract No. 87-34-69-01).

TABLE 20. ABSENCE RATES FOR FULL-TIME NONFARM WAGE AND SALARY WORKERS, BY REASON, MAY 1973 AND MAY 1978

	May 1973	May 1978
Number of Absences per 100 Workers		
Total (all reasons)	6.5	6.6
Illnesses or Injury	4.1	4.1
Miscellaneous reasons	2.4	2.5
Hours Absent per 100 Hours Usually Worked	3.5	3.5

SOURCE: Daniel E. Taylor, "Absent Workers and Lost Work Hours, May 1978," Monthly Labor Review (August 1979), p. 50.

does not appear to have changed significantly over the last 30 years. 23/

It is possible that nonwork values may have become relatively more important than in the past and that workers may have become less satisfied with their jobs. Some survey data suggest that workers may value leisure relatively more, and their careers less, than formerly, and that workers may also attach relatively more importance to nonpecuniary aspects of their jobs. 24/ One study

23/ Multiple regression was used to test whether there was a statistically significant time trend from 1948 to 1978 in the manufacturing quit rate, after adjusting for the cycle. The coefficient on the time variable was negative, although not statistically significant.

24/ See Jerome M. Rosow, "Changing Attitudes to Work and Life Styles," Journal of Contemporary Business, vol. 8, no. 4; and Work In America, Report of a Special Task Force to the Secretary of Health, Education, and Welfare (1974).

reports an appreciable drop in the overall job satisfaction of workers between 1973 and 1977, particularly among lower-income workers. 25/ The effect of high tax rates on work effort remains an open question. 26/

New approaches to organizing work, as well as more cooperation between labor and management in matters relating to productivity, may offer some promise. 27/ One example is the Scanlon plan approach to dividing the economic gains of productivity improvements between workers and the firm. Another example is the community effort in Jamestown, New York--which appeared to be a mature declining area--where labor-management cooperation helped in raising productivity and turning the situation around. More

---

25/ Robert P. Quinn and Graham L. Staines, The 1977 Quality of Employment Survey (University of Michigan, Institute for Social Research, 1979), pp. 303-09.

26/ Most research on the relation between labor supply and taxation has focused on quantitative rather than qualitative aspects. For a review of the literature, see Congressional Budget Office, An Analysis of the Roth-Kemp Tax Cut Proposal (October 1978), Chapter III.

27/ There have been numerous experiments or instances in which increased worker participation in decisionmaking or worker sharing in the benefits of increases in efficiency seem to have improved productivity. See, for example, National Center for Productivity and the Quality of Working Life, Recent Initiatives in Labor-Management Cooperation (1976); Raymond A. Katzell and others, A Guide to Worker Productivity Experiments in the United States, 1971-1975 (New York University Press, 1977); Edgar Weinberg, "Labor-Management Cooperation: A Report on Recent Initiatives," Monthly Labor Review, vol. 99, no. 4 (April 1976), pp. 13-22; and The Human Resources Development Act of 1977, Hearings before the Subcommittee on Economic Stabilization of the Committee on Banking, Finance and Urban Affairs, House of Representatives, 95:2 (1977). Such measures might improve the quality of life of workers in addition to improving productivity.

recently, the steel industry has taken steps to involve labor and management in cooperative efforts to raise productivity. 28/ The bulk of the case studies seem to suggest that such private-sector efforts tend to increase productivity.

Initiatives such as these are basically private-sector matters, outside the sphere of direct federal action. The government can, however, lend support. One possibility would be to increase the funding under Section 6 of CETA, which provides support for innovative approaches in labor-management relations. Certain changes in government policies might help to create a more favorable environment for labor-management cooperation. For example, modifying the unemployment insurance system to encourage work-sharing arrangements rather than layoffs during slack periods might improve the climate for worker-managment cooperation. In addition, the slack time could be used to form problem-solving committees or to implement other approaches to production problems.

While these may be promising approaches to increasing productivity, there is no way of estimating their likely impact. In addition, they may be limited by institutional factors. Traditionally, management has guarded its prerogatives in decision-making, while labor unions have been skeptical of programs to raise productivity. 29/

CONCLUSIONS

Two of the factors that have tended to slow productivity growth since the mid-1950s are beginning to slow or reverse: The labor force will probably expand much more slowly in the 1980s, and the proportion of inexperienced workers in the labor force will

---

28/ According to one recent source, this approach greatly increased productivity in a particular steel plant in Louisville, Ohio, run by the Jones and Laughlin Co. See "Worker Ideas Lift Steel Output," New York Times, October 17, 1980.

29/ This kind of "industrial democracy" seems to be more prominent in Western Europe and in Japan than in the United States, at least to date. In the United States, unions have tended to focus on wages and working conditions but not profit sharing, or measures to enhance the meaning of the job.

11-793 O - 82 - 4

likely decline. These two factors together might contribute as much as half of one percentage point to the productivity growth rate in the latter half of the decade.

Among policies affecting the labor force, those that would encourage training and better-quality secondary education seem likely to be a more effective means of stimulating productivity than would an across-the-board increase in investment in higher education. In addition, the federal government might employ a number of approaches--some experimental--to encourage the private sector in skill-development and more effective utilization of human resources.

CHAPTER V. POLICIES TO ENCOURAGE EFFICIENT TECHNOLOGIES

Innovation--the development of more efficient technologies and their application in industry--is one of the most important determinants of productivity growth. The innovative process, while not well understood, is believed to be influenced by such basic factors as the prospect of economic gain, the degree of uncertainty surrounding economic decisions, and the quality of business management. The government plays a secondary role in this process, but its actions influence the climate for innovation and it can encourage or discourage innovation through its policies in areas such as taxation, regulation of business, patent law, support for scientific investigation, and the dissemination of information. 1/

This chapter examines trends in innovation, to the extent that they can be gauged. A number of policy measures might improve the climate for innovation. Research and development could be encouraged by further tax incentives or by more direct forms of government involvement such as grants, loans, or price guarantees. Diffusion of new technologies could be encouraged by tax measures that would stimulate business capital spending. Small, high-technology businesses would benefit from targeted tax, credit, or regulatory measures.

TECHNOLOGICAL INNOVATION AND PRODUCTIVITY GROWTH

The importance of technological innovation in stimulating productivity growth is generally recognized by students of the

---

1/ In this report, "innovation" is used to mean technological progress--a broader meaning than is usually implied when economists use the term. It will include not only the phases of invention and of first commercial application, but also the phase of diffusion of an invention throughout an industry. Economists generally use "innovation" to mean the first two of these phases. See, for example, Edwin Mansfield, Technological Change (W.W. Norton, 1971), chap. 4.

subject. 2/ There is less agreement, however, about the importance of expenditures for research and development (R&D) or particular kinds of innovation, such as innovation by the small business firm, as determinants of productivity growth. Some investigators have attached much importance to R&D, and have seen it as a factor in the productivity slowdown after the mid-1960s. According to one source, as much as 0.9 percentage points of the productivity growth rate in the 1948 to 1966 period, as well as a substantial part of the slowdown after 1966 (0.3 percentage points), can be attributed to changes in the amounts spent on research and development. 3/ Some analysts, however, stress that R&D is only one aspect of innovation and that a substantial part of it--as in national defense--has little to do with measured productivity. According to this view, the slowdown in R&D spending was not an important factor in the overall productivity slowdown. 4/

In comparing specific industries and firms, however, researchers have found a relationship between the amounts spent on R&D and the rate of productivity growth. Variations in R&D spending over time within an industry or firm seem to influence productivity growth, although there is considerable uncertainty about the size and timing of such effects. 5/

2/ According to Edward Denison, the category of determinants "advances in knowledge and not elsewhere classified" accounted for as much as two-thirds of the growth in productivity in the 1948 to 1973 period. See Edward F. Denison, Accounting for Slower Economic Growth (Brookings Institution, 1979), p. 108.

3/ John W. Kendrick, "Productivity Trends and the Recent Slowdown: Historical Perspective, Causal Factors, and Policy Options," in William Fellner, ed., Contemporary Economic Problems (American Enterprise Institute, 1979), p. 33.

4/ Denison, Accounting for Slower Economic Growth, pp. 122-26.

5/ See Roger Brinner, Technology, Labor, and Economic Potential (Data Resources, Inc., 1978), chap. 1; Zvi Griliches, "R&D and the Productivity Slowdown," American Economic Review (May 1980), pp. 343-47; and M. Ishaq Nadiri, "Sectoral Productivity Slowdown," American Economic Review (May 1980), pp. 349-52.

Other evidence can be marshaled. The economic returns to businesses investing in research and development appear to be relatively high compared with alternative investments--at least as high as, and probably somewhat higher than, the returns from investments in plant and equipment. In addition to the increase in profits for the innovating firm, there are benefits accruing to other firms and to consumers. The social returns from R&D investments, which include private as well as external benefits, may be much higher than the private returns to the firm undertaking the R&D--according to some estimates as much as double the private returns. 6/ (These generalizations are based on experience before 1970. However, one paper that includes more recent data from the 1970s period suggests that the measured economic returns from R&D investments may have declined as compared with the 1960s.) 7/

TRENDS IN INNOVATION

A major difficulty in the study of innovation is that there is no direct measure of innovation that is meaningful for the economy. There are only indirect measures such as R&D spending, the number of patents awarded, or imports and exports in "high technology industries." It would be tempting to use the readily available figures for R&D as "a measure of the pace of innovation." But that

---

6/ See, for example, Edwin Mansfield, "Federal Support of Research and Development Activities," in Priorities and Efficiency in Federal Research and Development, Joint Economic Committee (1976), pp. 85-113; Brinner, Technology, Labor, and Economic Potential, pp. 95-100; Zvi Griliches, "Return to Research and Development Expenditures in the Private Sector," in J.W. Kendrick and B.N. Vaccara, eds., New Developments in Productivity Measurement and Analysis (University of Chicago Press, 1979), pp. 419-54; and A. Pakes and M. Schaukerman, "The Rate of Obsolescence of Knowledge, Research Gestation Lags, and the Private Rate of Return to Research Resources," National Bureau of Economic Research, Inc., Working Paper No. 346 (1979).

7/ Griliches, "R&D and the Productivity Slowdown." The paper also raises the possibility that there may have been an increase in the proportion of R&D that is devoted to either noneconomic purposes or to economic purposes that are not measured in the GNP accounts.

would be a mistake. Innovation is a comprehensive process that involves creative insight, commercial development, and diffusion of technology throughout an industry. R&D is an input to this process--not an end result. In some cases, a new technology can be copied from firms in another country without the need for R&D. Moreover, in some industries, R&D represents considerably less than half of the cost of developing a new technology. Finally, the diffusion or spread of the new technology throughout an industry is critical for productivity growth, yet that phase may take years or decades. This section discusses trends in several elements of the innovative process.

Trends in Research and Development Spending

Research and development activity in the United States increased sharply from the mid-1950s to the mid-1960s but slowed markedly afterward. As shown in Table 21, real R&D spending slowed to a growth rate of only 1.0 percent a year in 1965-1973 and 1.8 percent in 1973-1978. The slowdown in government spending for R&D--the government finances about one-half of total R&D--was considerably more pronounced than that in R&D financed by the private sector. The more rapid growth in privately financed R&D spending in 1978-1979 may indicate some resurgence.

TABLE 21. GROWTH IN REAL SPENDING FOR RESEARCH AND DEVELOPMENT, BY SOURCE OF FUNDS, 1953-1979 (Percent annual growth in 1972 dollars)

Period	Total R&D	Private Industry R&D	Federal Government R&D
1953-1965	9.9	7.2	11.7
1965-1973	1.0	4.5	-1.5
1973-1978	1.8	3.3	0.4
1978-1979	3.4 a/	4.5 a/	2.3 a/

SOURCE: National Science Foundation, National Patterns of Science and Technology Resources 1980, NSF 80-308 (1980), Table 5.

a/ Preliminary.

Expressed as a percent of GNP, total R&D spending increased from 1.6 percent in 1955 to 2.9 percent in 1965, and then declined to 2.3 percent in 1978 (see Table 22). R&D funded by private industry has continued at approximately 1.0 percent since the early 1960s.

TABLE 22. RESEARCH AND DEVELOPMENT SPENDING AS A PERCENT OF GROSS NATIONAL PRODUCT, SELECTED YEARS, 1955-1978

Year	Total a/	Carried Out by Industry b/	Funded by Industry
1955	1.55	1.16	0.62
1960	2.67	2.08	0.89
1965	2.91	2.06	0.95
1970	2.64	1.84	1.06
1973	2.35	1.63	1.02
1974	2.34	1.62	1.05
1975	2.32	1.58	1.04
1976	2.29	1.59	1.04
1977	2.26	1.58	1.04
1978	2.27	1.57	1.05

SOURCES: National Science Foundation and U.S. Department of Commerce.

a/ Includes government and private nonprofit sectors.

b/ Includes research and development carried out by private industry but financed by government.

In industry, the composition of R&D spending has shifted away from basic research and toward more applied research. Basic research made up approximately 7.0 percent of total R&D financed by private industry in 1965 but only 4.6 percent in 1973 and 4.3 percent in 1978. Considering all sources of funding, however, basic research did not decline as a share of total R&D spending.

(One reason is that federal R&D spending became more focused on basic research.) 8/

Total real spending for basic research (private and public) did not increase at all from the late 1960s through 1977, and it dipped substantially during the middle of this period. Trends in federal R&D spending contributed to the weakness during that period. Federal government spending for basic research, which accounts for about two-thirds of all spending for basic research, declined from $2.8 billion in 1968 (in 1972 dollars) to a low point of $2.5 billion in 1975, before returning to about $2.9 billion in 1978. In the private industry sector, real spending for basic research declined slightly in the 1968-1978 period. Nonprofit institutions increased their funding of basic research in this period, from $520 million to $660 million. 9/

The significance of the slowdown in R&D spending is difficult to interpret, since much of it has been associated with defense and space programs. While some breakthroughs in defense R&D have had very important commercial applications, economists believe that government-financed R&D tends to have a smaller direct impact on productivity than R&D financed by private industry. 10/ For example, a substantial part of federal R&D is support for such objectives as health, which are not measured in the national accounts. Also, government-sponsored R&D may have indirect effects on productivity in the industries that purchase goods and services from defense and space industries.

Inevitably, there is a lag between any change in R&D spending and its impact on productivity. For this reason, some analysts feel that the full impact of the slowdown in R&D spending, particularly on basic research, is yet to be felt.

8/ National Science Foundation, National Patterns of Science and Technology Resources 1980, NSF 80-308 (1980), Table 7.

9/ Ibid.

10/ See Nestor Terleckyj, "Direct and Indirect Effects of Industrial Research and Development on the Productivity Growth of Industries," in Kendrick and Vaccara, New Developments in Productivity, pp. 359-86.

International comparisons show that the United States still spends more on R&D in absolute terms than its major trading partners. But several of these countries have been increasing R&D spending at a more rapid rate and, relative to GNP, have about caught up with the United States (see Table 23). Both Germany and Japan spend more on nondefense R&D relative to GNP than the United

TABLE 23. RESEARCH AND DEVELOPMENT EXPENDITURES IN LEADING INDUSTRIAL COUNTRIES AS A PERCENT OF GROSS NATIONAL PRODUCT, 1963-1977

	1963	1967	1973	1977
United States	2.9	2.9	2.3	2.3
Canada	0.9	1.3	1.1	1.0
France	1.6	2.1	1.8	1.8
Germany	1.4	2.0	2.3	2.3
Japan	1.4	1.5	1.9	1.9 a/
United Kingdom	2.3 b/	2.3	2.1 c/	NA
USSR	2.8	2.9	3.7	3.5

SOURCE: National Science Foundation, Science Indicators 1978, p. 140.

a/ 1976.
b/ 1964.
c/ 1975.

States (see Table 24). Within the private sector, enterprise-funded research and development as a percent of GNP is about the same in Germany as in the United States, but it is higher in Japan. In 1973, the latest year for which published estimates seem to be available, privately financed research and development in manufacturing was a larger percent of value added in the United States than in Germany, but about the same as in Japan. If defense research carried out by manufacturing industry and financed by

TABLE 24. RESEARCH AND DEVELOPMENT EXPENDITURES EXCLUDING DEFENSE IN LEADING INDUSTRIAL COUNTRIES AS A PERCENT OF GROSS NATIONAL PRODUCT, 1961-1976

	1961	1967	1976
United States	1.3	1.9	1.6
France	1.0	1.6	1.5
Germany	NA	1.8	2.2
Japan	1.4	1.5	1.9 a/
United Kingdom	1.5	1.7	1.5 a/

SOURCES: U.S. Bureau of Labor Statistics and National Science Foundation, cited in Committee for Economic Development, Stimulating Technological Progress (1980), p. 26.

a/ 1975.

government is included, the United States outranked both Germany and Japan by a large margin (see Table 25).

Thus, conclusions drawn from international comparisons depend on what kind of R&D spending is being compared. U.S. government spending on R&D is relatively more concentrated on defense than is that of major U.S. trading partners; and other types of R&D spending by the U.S. government are relatively less focused on economic growth objectives (see Table 26).

Trends in Patents Granted

Another indicator of innovation is the number of U.S. patents granted per year, although that is a very crude measure because patents vary in their significance. The number of patents granted has declined substantially since 1973, and is at roughly the same